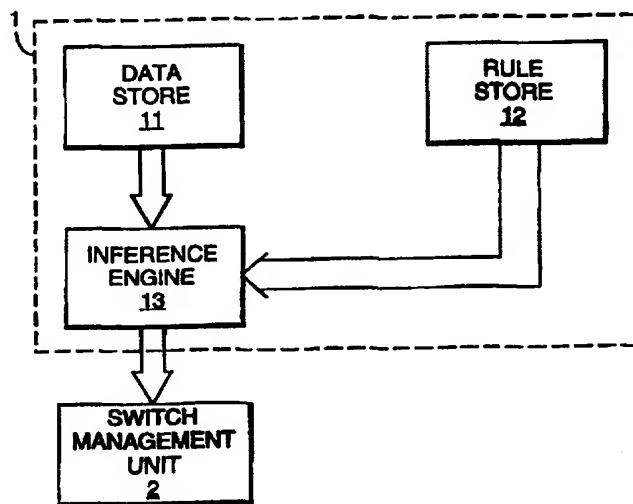




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(54) Title: DETECTING SERVICE INTERACTIONS IN A TELECOMMUNICATIONS NETWORK



## (57) Abstract

A system for detecting interaction between different services on a telecommunications network includes a computer expert system. A data store in the expert system is programmed with data which represent attributes of service features. A rule store is programmed with rules which relate feature attributes to interaction behaviours. An inference engine is connected to the data store and to the rule store and processes the data and the rules to detect any interaction between the services. The data in the data store may be arranged as sets of objects, each object in a set corresponding to a different state transition of the corresponding feature. The different objects may be given sequence numbers corresponding to the time sequence of execution of the feature. At least some of the rules may relate to these sequence numbers.

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## DETECTING SERVICE INTERACTIONS IN A TELECOMMUNICATIONS NETWORK

The present invention relates to telecommunications networks, and in particular to the detection of undesirable interactions between different services running on a network.

Telecommunications networks are increasingly required to offer customers services in addition to basic call-handling. The development of novel network architectures, such as the IN (intelligent network) architecture, together with developments in computing platforms for telecommunications systems, make it potentially possible to offer customers a large portfolio of additional services to select from. However, as the number of services increases, and as services become available from independent service providers in addition to the network operator, then service feature interaction becomes a serious problem. It is often found that features offered by one service interact in an unwanted manner with features of other services. For example, a voice messaging service, such as BT's CallMinder service, may have as one of its standard features a behaviour such that incoming calls are diverted to the messaging service whenever the called line is busy. Another available service, Call Waiting, handles the same condition, namely the called number being busy, in an entirely different fashion. The Call Waiting service transmits an alert tone to the user and gives the user the option of interrupting the on-going call to speak to the new caller. It can be seen that if a customer wanted to subscribe to both services, then there is conflict between the service features which needs to be resolved. Otherwise, it would be necessary to bar the provisioning of both of these services to a customer, with a consequent loss in utility to the customer, and loss of revenue to the service provider.

Conventionally, during the planning of new services for a telecommunications network, attempts have been made to detect in advance any interaction problems by writing English-language specifications of the service features. Using these specifications a paper "walk through" of the services is then conducted, with the design engineer going step by step through the different services and spotting any interaction problems. This is a time-consuming procedure which can never be completely reliable, leaving the possibility that unforeseen interactions will occur when the service is deployed.

Some attempts have been made previously to automate the detection of interaction during the design phase. For example, International patent application WO95/22231 discloses a method of detecting service interactions which uses formal specifications of the additional services. The algorithm uses information 5 that is specific to the services being tested which needs to be rewritten every time a change is made to one of the service features. Moreover, the approach adopted requires that a formal model should be prepared for every service feature which is handled. The preparation of such formal models is a difficult and time-consuming task requiring a high level of expertise.

10

According to a first aspect of the present invention, there is provided a system for detecting interaction between services running on a telecommunications network comprising:

- a computer expert system including:
- 15           a) a data store programmed with data representing attributes of service features;
- b) a rule store programmed with rules which relate feature attributes to interaction behaviours; and
- c) an inference engine which is connected to the data store and to the rule store and which is arranged to process the data and the rules, thereby detecting any interaction between the services.
- 20

The present invention adopts a radically new approach to the detection of service feature interaction, through the use of an expert system. The traditional domain of use of expert systems is for diagnostic classification problems involving 25 data which is essentially static. A well known example is the identification of a particular bacterium from a series of statements about its properties and appearance. In this domain, expert system technology has a proven track record in reproducing and sometimes surpassing human expert performance for the same problem. It is not however been thought possible hitherto to apply such 30 techniques to the problem domain of the present invention. Feature interaction in a telecommunications network is an essentially time-related phenomena and so on the face of it not suitable for expert system techniques. The present inventors have found however that with an appropriate knowledge representation, expert

systems can successfully be used for feature interaction detection. This provides a dramatic reduction in the time required to uncover service interworking problems, coupled with increased flexibility. The separation between the knowledge representation and the inference rules, means that changes or additions to the services can readily be assessed simply by making corresponding changes to the knowledge representation in the data store. In this way, the system is quickly able to detect any problems arising from the new features. By contrast with the prior art systems there is no need to repeat an entire "walk-through" from scratch.

The system of the present invention may run, for example, at a local switch in a telecommunications network to aid the detection and management of interaction problems as they occur. Alternatively, or in addition, the system may be used during the development of a new service to detect any interaction problems prior to the deployment of the service.

In the case of a system used at run-time in the network, then the output of the system may be fed to a control system for modifying the behaviour of the network in order to remove or ameliorate the detected interaction problem. The control system may, for example, modify the stored profile for a customer in order to disable one or more service features. A more sophisticated control system might initiate a dialogue with the customer to allow the customer to determine a default behaviour for the network. For example, in the case of the Call Minder or call waiting services, the user might be given the option of selecting the Call Waiting response, that is the transmission of an alert tone, rather than the Call Minder response, that is the transfer of the incoming call to a messaging service.

Preferably the expert system data store includes a plurality of objects including, for each service feature which is represented in the data store, a set of objects corresponding to different respective state transitions of the feature.

The term "object" is used in this document in the sense of object oriented design/programming (OOD/OOP) methodologies.

As discussed in further detail below, the choice of an appropriate structure for organising the data in the data store is critical in maximising the efficiency of the interaction detection system. The inventors have found that the combination of the use of an object-based structure and a state transition representation of the service feature offers significant advantages both in efficiency of operation and in

ease of development and modification of the detection system. The use of sets of objects representing different state transitions makes it possible to capture the characteristics of a service feature in a form which is well-adapted for processing by the inference engine.

- 5 Preferably each of the said set of state transition objects includes a sequence number corresponding to the position of the respective state transition in the sequence of execution of the feature and at least some of the rules in the rule store reason over the values of the sequence numbers. Preferably the objects are arranged in a hierarchy of superclasses and subclasses of the superclasses, and  
10 some of the rules reason over superclasses and others of the rules reason over subclasses.

The use of objects belonging to a hierarchy of classes, combined with rules which operate at different levels of the class hierarchy further increases the flexibility of the system. In particular, it ensures that when a new object is added  
15 to the data store, for example as the result of a modification to a service feature, there will already exist rules functioning at a higher level of the hierarchy which are immediately applicable to the new object, so that extensive modification of the rules is not required.

According to a second aspect of the present invention there is provided a  
20 method of detecting interaction between services running on a telecommunications network comprising:

programming a computer expert system with data representing attributes of service features and with rules relating feature attributes to interaction behaviours;

25 processing the said data and the said rules in an inference engine and detecting thereby any interaction between the said services.

According to a third aspect of the present invention, there is provided a method of operating a telecommunications network comprising:

30 programming a computer expert system with data representing attributes of service features and with rules relating feature attributes to interaction behaviours;

processing the said data and the said rules in an inference engine and detecting thereby any interaction between the said services; and

modifying the operation of the network when an interaction is detected.

Systems and methods embodying the present invention will now be described in further detail, by way of example only, with reference to the accompanying drawings in which:

5       Figure 1 is a schematic of a system for detecting service feature interaction;

Figure 2 is a schematic of a network having an IN architecture;

Figure 3 is a state transition diagram illustrating one example of a service feature;

10      Figure 4 is a class diagram showing the structure of the objects in the data store of the system of Figure 1;

Figure 5 shows the structure of the switch management unit;

Figure 6 shows a multiprocessor system for implementing the expert system of Figure 1.

15      A system for detecting and managing interactions between services running on a telecommunications network comprises an expert system 1 which in this example is connected to a switch management unit 2 within a service switching point (SSP) 3. As shown in Figure 2, the service switching point forms part of a telecommunications network employing an IN (intelligent network)

20      architecture and including a further SSP 4, a service control point (SCP) 5 and an intelligent peripheral 6. The network, other than in the features described in further detail below, is conventional in nature. For further details of the IN architecture reference is made to the paper by T W Abernethy & A C Munday,

"Intelligent Networks, Standards and Services", BT Technol J, Vol. 13, No. 2, April

25      1995 and to the European Telecommunications Standards Institute Final Draft PRETS 300374-1, published July 1994, the contents of both of which are incorporated herein by reference.

The call control software within the switch management unit is structured as described in the paper by HM Blair, "Attacking Product Complexity: Broadband

30      Call Control for Vision O.N.E" XIV International Switching Symposium, October 25-30 1992. Figure 5 shows the software structured into a chain of connection segments. In this software structure it is the responsibility of the User Transaction Segment (UTS) to invoke feature software and link it into the chain, based on

customers' service data. In this example application of the feature interaction expert system, the expert system forms part of the UTS. The expert system gets its input facts from the customer data and/or call progress signalling and the results of processing are used to decide whether to invoke feature software and if 5 so, where in the call chain to link that software.

The expert system 1 includes a data store 11, a rule store 12 and an inference engine 13. In this example, the hardware for the expert system comprises a distributed processing system using Pentium microprocessors with access to local RAM and to mass storage devices. The data store 11 and rule 10 store 12 are embodied in the storage devices and in the local RAM, and the inference engine 13 is provided by appropriate programming of the Pentium microprocessors.

Figure 6 shows in further detail the platform used in this example to support the expert system. Multiple Pentium CPU's are linked by a local bus to 15 each other, and to the region of RAM. Data stored on a local hard disk is accessed via a SCSI interface. The multiprocessor system is implemented on a motherboard which is linked to other components of the switch by an FDDI optical fibre LAN. In this example, in order to facilitate the use of an object-oriented knowledge representation, the expert system is implemented using an expert systems shell 20 available commercially from Neuron Data Inc. of Mountain View, CA as "NEXPERT OBJECT" (Trade Mark). This is an object-based expert systems implementation tool with facilities for implementation of rules in the C programming language. The implementation of the rules is based on first order predicate logic.

The expert system operates by applying rules to facts. The facts may 25 have been input to the expert system either manually by the human user, or by a call control programme. Alternatively, the facts may have been inferred by previous applications of the rules. The evaluation of a rule assigns a truth value to the hypothesis of the rule, which represents some new fact about the domain. As rules may trigger other rules in their predicate actions, a set of rules comprises a 30 network through which simple conclusions may be propagated to arrive at more complex results.

It is found to be important that an appropriate form of knowledge representation is used for the facts. This is particularly true for the problem

domain of the present invention. As discussed in the introduction above, feature interaction is a characteristically time-related phenomenon, whereas expert systems have traditionally been applied to static diagnostic or classification problems. The preferred implementation of the present invention uses an object-based knowledge representation, in which the objects are derived from state transition models of the service features. A state transition model offers the functionality necessary to describe service features, provided that note is taken of the side effects of the transitions between the various states. It is the side effects that will lead to models becoming interdependent and hence interacting within the network. A telephony feature may make a state transition for a variety of reasons, including response to an event caused by a state transition for some other feature.

In the knowledge representation adopted in the present invention, the data store 11 is programmed with objects corresponding to the state transition of a finite state machine representing the behaviour of a telephony feature. As shown in Figure 4, the objects belong to classes which define a template for feature state transition objects.

It should be noted that the class does not relate to an instance of the feature acting on a particular call, but describes how the feature will behave depending on its context in a particular call. Rules may then be written concerning behaviour of members of these classes, without reference to actual values of call data.

Figure 3 is a state transition diagram representation of a service feature. In this example the service is an account code service, such as BT's chargecard service. Figure 4 is a class diagram showing the objects used to represent such a feature in a system embodying the present invention. Figure 4 uses the OMT diagram conventions set out in "Object Oriented Modeling & Design", Rumbaugh et al., Prentice Hall, ISBN 0-13-630054-5. As shown in the Figure, the account code service comprises four state transitions, referenced a-d. Within the knowledge base of the expert system, the feature is stored as an instance of the ServiceFeature class, comprising a name "ACCCode" and a set of four Feature Transition objects:

**Transition a:****Sequence no. - 1****Trigger event -**

5           event type - dialled digits  
         location - calling party  
         data - 145

**Caused event -**

10          event type - announcement  
         location- calling party  
         data - character string "A/C no. ?"

**15 Transition b:****Sequence no. - 2****Trigger event -**

20          event type - mid-call dialled digits  
         location - calling party  
         data - e.g. 56789 (valid)

**Caused event -**

25          event type - announcement  
         location- calling party  
         data - character string "Enter no. ?"

**Transition c:****30 Sequence no. - 2****Trigger event -**

         event type - dialled digits

location - calling party  
data - e.g. 34567 (not valid)

Caused event -

5           event type -clear call  
              location- general  
              data -

Transition d:

10           Sequence no. - 3

Trigger event -

15           event type - mid-call dialled digits  
              location - calling party  
              data - e.g. 01473 644668

Caused event -

20           event type -call event  
              location- general  
              data - e.g. 01473 644668

In developing the rules programmed in the rule store 12, use was made of a set of high level rules developed for this problem domain. These rules are 25 grouped in terms of key words which collect the rules into concept groupings. The rules were then formalised and decomposed into smaller grains of knowledge to allow their implementation. Rules of small semantic weight use facts input to the experts system to extract simple conclusions. The simple conclusions are then forwarded through the rule network for use by one or more rules at a higher level. 30 These larger semantic weight rules eventually form conclusions which correspond directly to the English language definitions of the top level rules.

As information is forwarded through the rule network, some re-use of the lower level rules is achieved. Simple components of knowledge which are useful

in the implementation of one high level rule often recur in the conditions of another rule. The choice of rules used in the implementation affects the level of reusability which is achieved. An efficient implementation is arrived at by progressive refinement of the choice of low level rules used. The rule evaluation process 5 moves up through the rule network from data to higher level conclusions. The successful evaluation of a rule often leads to a subset of the feature state transition objects existing within the knowledge base being associated with a conclusion. When this occurs, a class is created dynamically corresponding to the subset of feature states. Those of the higher level rules which make use of the 10 associated hypotheses then generally operate on the subset of feature state transition objects rather than the complete set, thus progressively constraining the scope of this subset and eventually arriving at a smaller one showing some interaction.

Tables 2.1-2.5 show examples of the rules from the rule store 12. It can 15 be seen that hypothesis of low semantic weight such as "trigger location compatible" lead to hypothesis with semantic weight corresponding to the original English language rules such as "triggering conflict". Table 2.4 shows a rule operating on the feature transition attribute "sequence number" to infer that a particular service feature is "persistent" (it remains associated with a call after its 20 initial actions when triggered). Table 2.5 shows a rule operating on objects belonging to the super-class "run time event" to infer that a particular service feature initiates a new call as part of its actions.

In use, when operation of the inference engine results in the hypothesis of rule 2.3 having the value "TRUE" then this result may be acted on by the switch 25 management unit 2 to modify or inhibit one or more of the features running on the switch, so as to resolve the conflict arising from the feature interaction problem. For the particular call control software architecture illustrated in Figure 5, this involves the User Transaction Segment (UTS) either not invoking the Feature Segement (FS) corresponding to one of the features concerned or modifying the 30 positions in the call chain of the relevant FSs.

TABLE 2.1

If < | feature\_transition | >.trigger\_event\_location equals "remote"  
 5 And < | feature\_transition | >.trigger\_event\_location equals  
 next\_feature\_transition.trigger\_event\_location  
 Then trigger\_locations\_compatible  
 Action Create Object < | feature\_transition | >|location\_compatible\_transition |

10

TABLE 2.2

If trigger\_locations\_compatible  
 And < | location\_compatible\_transition | >.trigger\_event\_location equals "remote"  
 And < | location\_compatible\_transition | >.dest\_line\_state equals next\_feature\_transition.  
 15 dest\_line\_state  
 Then line\_transition\_compatible  
 Action Create Object < | location\_compatible\_transition | > | compatible\_transition |

TABLE 2.3

20

If line\_states\_compatible  
 And < | compatible\_transition | >.trigger\_event\_type equals  
 next\_feature\_transition.trigger\_event\_type  
 And < | compatible\_transition | >.local\_line\_state equals  
 25 next\_feature\_transition.local\_state  
 Then triggering\_conflict

TABLE 2.4

30 Rule using the Feature\_transition attribute "Sequence number"

If < | service feature | >.< | feature\_transitions | >.sequence\_number.1  
 Then persistent feature  
 Action Ceate Object < | service feature | > | persistent\_features |

**TABLE 2.5**

Rule using the "Run time event" class

- 5   **If**<|service feature|>.<|run time\_event|>.event\_type equals "new call"  
The multiple calls feature  
Action Create Object<|service\_feature|>|multiple\_calls\_features|

## Appendix A - Example expert system

- The following definitions document an expert system embodying the invention. The first section describes the expert system in terms of the class structures of the knowledge base, the static objects in the knowledge base and the rules which act on objects in the knowledge base. The second section is a snap-shot of the objects in the expert system after details of several service features have been added to it. The definitions are printed out from the *Nexpert Object™* tool in the format as documented by the Nexpert object reference manual (January 1991), part number Man-10-400-01.
- 10 A basic understanding of object oriented principles as well as expert system basics are assumed. Simple types used are Boolean (B), Integer (I) and String (S).
- Expert system definition**
- Class definitions**
- NAME : announce\_history  
15
- NAME : cascade\_attach  
PROPERTIES :  
feature\_name = (S) Unknown
- 20 NAME : compatible\_states  
PROPERTIES :  
local\_line\_state = (S) Unknown  
trigger\_event\_type = (S) Unknown
- 25 NAME : conflicting\_local\_announcement  
NAME : conflicting\_remote\_announcement
- NAME : control\_codes  
30 PROPERTIES :  
cascade\_attachments = (S) Unknown  
caused\_local\_event = (S) Unknown  
caused\_remote\_event1 = (S) Unknown  
caused\_remote\_event2 = (S) Unknown
- 35 dest\_line1\_state = (S) Unknown  
dest\_line2\_state = (S) Unknown  
feature\_name = (S) Unknown  
local\_line\_state = (S) Unknown  
location\_attachments = (S) Unknown
- 40 rank = (I) Unknown

sequence\_number = (I) Unknown  
trigger\_event\_location = (S) Unknown  
trigger\_event\_type = (S) Unknown

5 NAME : feature\_states  
SUBCLASSES :  
states\_compatible\_return  
returned\_lsc  
lsc\_out

10 working\_feature\_states  
triggering\_conflicts  
control\_codes  
PROPERTIES :  
cascade\_attachments = (S) Unknown

15 NAME : feature\_states.cascade\_attachments  
caused\_local\_event = (S) Unknown  
caused\_remote\_event1 = (S) Unknown  
caused\_remote\_event2 = (S) Unknown

20 dest\_line1\_state = (S) Unknown  
dest\_line2\_state = (S) Unknown  
feature\_name = (S) Unknown  
local\_line\_state = (S) Unknown  
location\_attachments = (S) Unknown

25 rank = (I) Unknown  
sequence\_number = (I) Unknown  
trigger\_event\_location = (S) Unknown  
trigger\_event\_type = (S) Unknown

30 NAME : location\_compatible\_states  
PROPERTIES :  
dest\_line1\_state = (S) Unknown  
local\_line\_state = (S) Unknown  
trigger\_event\_location = (S) Unknown

35 NAME : lsc\_out  
PROPERTIES :  
cascade\_attachments = (S) Unknown  
caused\_local\_event = (S) Unknown

40 caused\_remote\_event1 = (S) Unknown  
caused\_remote\_event2 = (S) Unknown  
dest\_line1\_state = (S) Unknown  
dest\_line2\_state = (S) Unknown  
feature\_name = (S) Unknown

45 local\_line\_state = (S) Unknown  
location\_attachments = (S) Unknown

rank = (I) Unknown  
sequence\_number = (I) Unknown  
trigger\_event\_location = (S) Unknown  
trigger\_event\_type = (S) Unknown

5 NAME : names\_attached  
PROPERTIES :  
feature\_name = (S) Unknown  
trigger\_event\_location = (S) Unknown

10 NAME : old\_value  
  
NAME : old\_values  
PROPERTIES :  
15 feature\_name = (S) Unknown  
  
NAME : possible\_features  
PROPERTIES :  
caused\_local\_event = (S) Unknown  
20 caused\_remote\_event1 = (S) Unknown  
caused\_remote\_event2 = (S) Unknown  
feature\_name = (S) Unknown  
trigger\_event\_location = (S) Unknown

25 NAME : returned\_lsc  
PROPERTIES :  
cascade\_attachments = (S) Unknown  
caused\_local\_event = (S) Unknown  
caused\_remote\_event1 = (S) Unknown  
30 caused\_remote\_event2 = (S) Unknown  
dest\_line1\_state = (S) Unknown  
dest\_line2\_state = (S) Unknown  
feature\_name = (S) Unknown  
local\_line\_state = (S) Unknown  
35 location\_attachments = (S) Unknown  
rank = (I) Unknown  
sequence\_number = (I) Unknown  
trigger\_event\_location = (S) Unknown  
trigger\_event\_type = (S) Unknown

40 NAME : states\_compatible\_return  
PROPERTIES :  
cascade\_attachments = (S) Unknown  
caused\_local\_event = (S) Unknown  
45 caused\_remote\_event1 = (S) Unknown  
caused\_remote\_event2 = (S) Unknown

dest\_line1\_state = (S) Unknown  
 dest\_line2\_state = (S) Unknown  
 feature\_name = (S) Unknown  
 local\_line\_state = (S) Unknown  
**5** location\_attachments = (S) Unknown  
 rank = (I) Unknown  
 sequence\_number = (I) Unknown  
 trigger\_event\_location = (S) Unknown  
 trigger\_event\_type = (S) Unknown

10

NAME : triggering\_conflicts  
 PROPERTIES :  
 cascade\_attachments = (S) Unknown  
 caused\_local\_event = (S) Unknown  
**15** caused\_remote\_event1 = (S) Unknown  
 caused\_remote\_event2 = (S) Unknown  
 dest\_line1\_state = (S) Unknown  
 dest\_line2\_state = (S) Unknown  
 feature\_name = (S) Unknown  
**20** local\_line\_state = (S) Unknown  
 location\_attachments = (S) Unknown  
 rank = (I) Unknown  
 sequence\_number = (I) Unknown  
 trigger\_event\_location = (S) Unknown  
**25** trigger\_event\_type = (S) Unknown

NAME : working\_feature\_states  
 PROPERTIES :  
 cascade\_attachments = (S) Unknown  
**30** caused\_local\_event = (S) Unknown  
 caused\_remote\_event1 = (S) Unknown  
 caused\_remote\_event2 = (S) Unknown  
 dest\_line1\_state = (S) Unknown  
 dest\_line2\_state = (S) Unknown  
**35** feature\_name = (S) Unknown  
 local\_line\_state = (S) Unknown  
 location\_attachments = (S) Unknown  
 rank = (I) Unknown  
 sequence\_number = (I) Unknown  
**40** trigger\_event\_location = (S) Unknown  
 trigger\_event\_type = (S) Unknown

**Properties definitions**

NAME : cascade\_attachments

TYPE : String

NAME : caused\_local\_event  
TYPE : String

NAME : caused\_remote\_event1  
5 TYPE : String

NAME : caused\_remote\_event2  
TYPE : String

10 NAME : dest\_line1\_state  
TYPE : String

NAME : dest\_line2\_state  
TYPE : String

15 NAME : feature\_name  
TYPE : String

NAME : local\_line\_state  
20 TYPE : String

NAME : location\_attachments  
TYPE : String

25 NAME : rank  
TYPE : Integer

NAME : returnval  
TYPE : Integer

30 NAME : sequence\_number  
TYPE : Integer

NAME : trigger\_event\_location  
35 TYPE : String

NAME : trigger\_event\_type  
TYPE : String

40 NAME : Value  
TYPE : Special

**Rules definitions**

RULE : Rule 29

If

45 there is evidence of incremental\_state\_development

And there is no evidence of cascade\_triggering\_exists  
 And <feature\_states>.feature\_name is equal to next\_feature\_state.feature\_name  
 And (next\_feature\_state.sequence\_number-<feature\_states>.sequence\_number) is precisely equal to 1  
 And Execute

5 "RankList"(@ATOMID=<feature\_states>;@STRING="@"@RANKBY=cascade\_attachments,@RANKSET=rank,@INCREASING";)  
 And <feature\_states>.rank is precisely equal to 1  
 And next\_feature\_state.cascade\_attachments is not equal to "dummy"  
 And next\_feature\_state.location\_attachments is not equal to "dummy"  
 10 Then Execute "add\_cascade"(@ATOMID=next\_feature\_state,<feature\_states>);  
 Then cascade\_history  
 is confirmed.

RULE : Rule 2

15 If  
 there is evidence of incremental\_state\_development  
 And there is no evidence of cascade\_triggering\_exists  
 And <feature\_states>.feature\_name is equal to next\_feature\_state.feature\_name  
 And (next\_feature\_state.sequence\_number-<feature\_states>.sequence\_number) is precisely equal to 1  
 20 And Execute  
 "RankList"(@ATOMID=<feature\_states>;@STRING="@"@RANKBY=cascade\_attachments,@RANKSET=rank,@INCREASING";)  
 And <feature\_states>.rank is precisely equal to 1  
 And next\_feature\_state.cascade\_attachments is not equal to "dummy"  
 25 And next\_feature\_state.location\_attachments is not equal to "dummy"  
 And Execute "add\_cascade"(@ATOMID=next\_feature\_state,<feature\_states>);  
 Then cascade\_history  
 is confirmed.

30 RULE : Rule 1  
 If  
 there is evidence of incremental\_state\_development  
 And there is evidence of cascade\_triggering\_exists  
 And <feature\_states>.feature\_name is equal to next\_feature\_state.feature\_name  
 35 And (next\_feature\_state.sequence\_number-<feature\_states>.sequence\_number) is precisely equal to 1  
 And Execute  
 "RankList"(@ATOMID=<feature\_states>;@STRING="@"@RANKBY=cascade\_attachments,@RANKSET=rank,@INCREASING";)  
 And <feature\_states>.rank is precisely equal to 1  
 40 And next\_feature\_state.cascade\_attachments is not equal to "dummy"  
 And next\_feature\_state.location\_attachments is not equal to "dummy"  
 And Execute "add\_cascade"(@ATOMID=next\_feature\_state,<feature\_states>,<lsc\_out>);  
 Then cascade\_history  
 is confirmed

45 RULE : Rule 6

```

If
  <|working_feature_states|>.trigger_event_type is equal to next_feature_state.caused_remote_event1
  And <|working_feature_states|>.trigger_event_location is precisely equal to "remote"
  And next_feature_state.dest_line1_state is not equal to "police"
5   And Delete Object |returned_lsc|
    And Delete Object |lsc_out|
    And Create Object <|working_feature_states|> |lsc_out|
    And
      Execute
      "line_states_compatible"(&ATOMID=|lsc_out|.next_feature_state;&STRING="local_line_state.dest_line1_state";)
10 Then cascade_triggering_exists
     is confirmed

RULE : Rule 5
If
15   <|working_feature_states|>.trigger_event_type is equal to next_feature_state.caused_local_event
    And <|working_feature_states|>.trigger_event_location is precisely equal to "remote"
    And next_feature_state.local_line_state is not equal to "police"
    And Delete Object |lsc_out|
    And Delete Object |returned_lsc|
20   And Create Object <|working_feature_states|> |lsc_out|
    And
      Execute
      "line_states_compatible"(&ATOMID=|lsc_out|.next_feature_state;&STRING="dest_line1_state.local_line_state";)
Then cascade_triggering_exists
     is confirmed
25

RULE : Rule 4
If
  <|working_feature_states|>.trigger_event_type is equal to next_feature_state.caused_remote_event2
  And <|working_feature_states|>.trigger_event_location is precisely equal to "local"
30   And next_feature_state.dest_line2_state is not equal to "police"
    And Delete Object |lsc_out|
    And Delete Object |returned_lsc|
    And Create Object <|working_feature_states|> |lsc_out|
    And
      Execute
      "line_states_compatible"(&ATOMID=|lsc_out|.next_feature_state;&STRING="local_line_state.dest_line2_state";)
35 Then cascade_triggering_exists
     is confirmed

RULE : Rule 3
40 If
  <|working_feature_states|>.trigger_event_type is equal to next_feature_state.caused_remote_event1
  And <|working_feature_states|>.trigger_event_location is precisely equal to "local"
  And next_feature_state.dest_line1_state is not equal to "police"
  And Delete Object |returned_lsc|
45   And Delete Object |lsc_out|
    And Create Object <|working_feature_states|> |lsc_out|

```

Execute

And  
 "line\_states\_compatible"('i'ATOMID=|lsc\_out.next\_feature\_state;@STRING="local\_line\_state.dest\_line1\_state";)  
 Then cascade\_triggering\_exists  
 is confirmed.

5 RULE : Rule 7  
 If  
 there is evidence of possible\_features\_listed  
 And <|feature\_states|>.trigger\_event\_type is precisely equal to "control code"  
 10 And <|feature\_states|>.feature\_name is equal to <|possible\_features|>.feature\_name  
 And <|possible\_features|>.trigger\_event\_location is precisely equal to "local"  
 And Create Object <|feature\_states|> |control\_codes|  
 Then control\_code\_history  
 is confirmed

15 RULE : Rule 8  
 If  
 <|feature\_states|>.feature\_name is equal to next\_feature\_state.feature\_name  
 And <|feature\_states|>.sequence\_number is equal to next\_feature\_state.sequence\_number  
 20 Then duplicate\_state  
 is confirmed

RULE : Rule 9  
 If  
 25 <|feature\_states|>.feature\_name is equal to next\_feature\_state.feature\_name  
 And <|feature\_states|>.caused\_local\_event is precisely equal to "announcement"  
 And Create Object <|feature\_states|> |announce\_history|  
 Then history\_built  
 is confirmed

30 RULE : Rule 11  
 If  
 <|feature\_states|>.feature\_name is equal to next\_feature\_state.feature\_name  
 And Delete Object |working\_feature\_states|  
 35 And Create Object <<|feature\_states|>> |working\_feature\_states|  
 Then incremental\_state\_development  
 is confirmed

RULE : Rule 10  
 40 If  
 <|feature\_states|>.feature\_name is equal to next\_feature\_state.feature\_name  
 And Delete Object |working\_feature\_states|  
 And Create Object <<|feature\_states|>> |working\_feature\_states|  
 And (<|feature\_states|>.sequence\_number-next\_feature\_state.sequence\_number) is greater than or equal to 0  
 45 And Delete Object <|feature\_states|> |working\_feature\_states|  
 Then incremental\_state\_development

is confirmed.

**RULE : Rule 12**

If

- 5        there is evidence of trigger\_locations\_compatible  
       And next\_feature\_state.local\_line\_state is not equal to "police"  
       And next\_feature\_state.dest\_line1\_state is not equal to "police"  
       And Execute "feature\_states\_compatible"(/ $\theta$ ATOMID=|location\_compatible\_states|.next\_feature\_state.)

Then line\_states\_ok

- 10      is confirmed

**RULE : Rule 15**

If

- 15      there is evidence of possible\_features\_listed  
       And <|possible\_features|>.caused\_local\_event is precisely equal to "announcement"  
       And <|names\_attached|>.feature\_name is equal to <|possible\_features|>.feature\_name  
       And <|names\_attached|>.trigger\_event\_location is precisely equal to "remote"  
       And <|possible\_features|>.feature\_name is equal to <|names\_attached|>.feature\_name  
       And Create Object <|possible\_features|> |conflicting\_local\_announcement|
- 20     Then local\_announcement\_conflict  
          is confirmed.

**RULE : Rule 14**

If

- 25      there is evidence of possible\_features\_listed  
       And <|possible\_features|>.caused\_remote\_event1 is precisely equal to "announcement"  
       And <|names\_attached|>.feature\_name is equal to <|possible\_features|>.feature\_name  
       And <|names\_attached|>.trigger\_event\_location is precisely equal to "local"  
       And <|possible\_features|>.feature\_name is equal to <|names\_attached|>.feature\_name  

30     Then local\_announcement\_conflict  
          is confirmed.

**RULE : Rule 13**

- 35     If

- there is evidence of possible\_features\_listed  
           And <|possible\_features|>.caused\_remote\_event2 is precisely equal to "announcement"  
           And <|names\_attached|>.feature\_name is equal to <|possible\_features|>.feature\_name  
           And <|names\_attached|>.trigger\_event\_location is precisely equal to "local"  

40     Then local\_announcement\_conflict  
          is confirmed.

- 45     RULE : Rule 16

If

there is no evidence of incremental\_state\_development  
 And Delete Object |working\_feature\_states|  
 And Create Object |feature\_states| |working\_feature\_states|  
 Then new\_feature\_development

5 is confirmed.

**RULE : Rule 17**

If

there is evidence of cascade\_history  
 10 And Execute "mv\_length"(@ATOMID=next\_feature\_state.cascade\_attachments.temp.returnval;)  
 And Execute "create\_objs"(@ATOMID=temp.returnval,[names\_attached];@STRING="attached\_name";)  
 And  
 "GetMultiValue"(@ATOMID=next\_feature\_state.cascade\_attachments.<names\_attached>.feature\_name;@STRING="@STRAT=SETFWRD";)  
 15 And Execute  
 "GetMultiValue"(@ATOMID=next\_feature\_state.location\_attachments.<names\_attached>.trigger\_event\_location;)  
 And <feature\_states>.feature\_name is equal to <names\_attached>.feature\_name  
 And Create Object <feature\_states> |possible\_features|  
 Then possible\_features\_listed

20 is confirmed.

**RULE : Rule 19**

If

there is evidence of possible\_features\_listed  
 25 And <possible\_features>.caused\_remote\_event2 is precisely equal to "announcement"  
 And <names\_attached>.feature\_name is equal to <possible\_features>.feature\_name  
 And <names\_attached>.trigger\_event\_location is precisely equal to "local"  
 And <possible\_features>.feature\_name is equal to <names\_attached>.feature\_name  
 And Create Object <possible\_features> |conflicting\_remote\_announcement|  
 30 Then remote\_announcement\_conflict  
 is confirmed.

**RULE : Rule 18**

If

35 there is evidence of possible\_features\_listed  
 And <possible\_features>.caused\_remote\_event1 is precisely equal to "announcement"  
 And <names\_attached>.feature\_name is equal to <possible\_features>.feature\_name  
 And <names\_attached>.trigger\_event\_location is precisely equal to "local"  
 And <possible\_features>.feature\_name is equal to <names\_attached>.feature\_name  
 40 And Create Object <possible\_features> |conflicting\_remote\_announcement|  
 Then remote\_announcement\_conflict  
 is confirmed.

**RULE : Rule 20**

45 If Execute "report"()

Then report\_generated  
is confirmed

RULE : Rule 21

5 If  
     Execute "SetMultiValue"("a@ATOMID=next\_feature\_state.cascade\_attachments:@STRING=@ADD=Call Waiting,  
Call Diversion, Call Divert on Busy, @NODUPLICATE,@COMP=STRING")  
     And Execute "SetMultiValue"("a@ATOMID=next\_feature\_state.location\_attachments:@STRING=@ADD=local,  
local, remote,@DUPLICATE,@COMP=STRING")  
 10     And Execute "add\_cascade"("a@ATOMID=next\_feature\_state:@STRING="Call Back When Free, local";)  
 Then test  
     is confirmed.

RULE : Rule 22

15 If  
     next\_feature\_state.dest\_line1\_state is not equal to "police"  
     And  
         Execute "line\_states\_compatible"("a@ATOMID=[feature\_states].next\_feature\_state:@STRING="local\_line\_state.dest\_line1\_state";)  
 Then test2  
 20     is confirmed.

RULE : Rule 24

If  
     <|feature\_states|>.trigger\_event\_location is precisely equal to "local"  
 25     And <|feature\_states|>.trigger\_event\_location is equal to next\_feature\_state.trigger\_event\_location  
 Then trigger\_locations\_compatible  
     is confirmed  
     And Create Object <|feature\_states|> |location\_compatible\_states|

30 RULE : Rule 23

If  
     <|feature\_states|>.trigger\_event\_location is precisely equal to "remote"  
     And <|feature\_states|>.trigger\_event\_location is equal to next\_feature\_state.trigger\_event\_location  
 Then trigger\_locations\_compatible  
 35     is confirmed.  
     And Create Object <|feature\_states|> |location\_compatible\_states|

RULE : Rule 28

If  
 40     there is evidence of line\_states\_ok  
     And <|states\_compatible\_return|>.trigger\_event\_type is equal to next\_feature\_state.trigger\_event\_type  
     And Create Object <|states\_compatible\_return|> |triggering\_conflicts|  
 Then triggering\_conflict  
     is confirmed.

45 RULE : Rule 27

If  
 <feature\_states>.trigger\_event\_type is equal to next\_feature\_state.caused\_local\_event  
 And <feature\_states>.local\_line\_state is equal to next\_feature\_state.local\_line\_state  
 And Create Object <feature\_states> |triggering\_conflicts|

5 Then triggering\_conflict  
 is confirmed.

RULE : Rule 26  
 If  
 10 <feature\_states>.trigger\_event\_type is equal to next\_feature\_state.caused\_remote\_event  
 And <feature\_states>.dest\_line1\_state is equal to next\_feature\_state.dest\_line1\_state  
 And Create Object <feature\_states> |triggering\_conflicts|  
 Then triggering\_conflict  
 is confirmed.

15 RULE : Rule 25  
 If  
 <feature\_states>.trigger\_event\_type is equal to next\_feature\_state.caused\_remote\_event2  
 And <feature\_states>.dest\_line1\_state is equal to next\_feature\_state.dest\_line1\_state  
 20 And Create Object <feature\_states> |triggering\_conflicts|  
 Then triggering\_conflict  
 is confirmed.

**List of hypotheses**

cascade_history:	Unknown
25 cascade_triggering_exists:	Unknown
* control_code_history:	Unknown
* duplicate_state:	Unknown
* history_built:	Unknown
incremental_state_development:	Unknown
30 line_states_ok:	Unknown
* local_announcement_conflict:	Unknown
* new_feature_development:	Unknown
possible_features_listed:	Unknown
* remote_announcement_conflict:	Unknown
35 * report_generated:	Unknown
* test:	Unknown
* test2:	Unknown
trigger_locations_compatible:	Unknown
* triggering_conflict:	Unknown

***Snap-shot of objects in the expert system after details of several service features have been added***

**Objects describing the *Call back when free* feature**

```

5   NAME : CBWF1
    CLASSES :
      feature_states
    PROPERTIES :
      cascade_attachments =      (S) none
10
    NAME : CBWF1.cascade_attachments
      caused_local_event =      (S) announcement

    NAME : CBWF1.caused_local_event
15   caused_remote_event1 =      (S) none

    NAME : CBWF1.caused_remote_event1
      caused_remote_event2 =      (S) none

20   NAME : CBWF1.caused_remote_event2
      dest_line1_state =      (S) any

    NAME : CBWF1.dest_line1_state
      dest_line2_state =      (S) any
25
    NAME : CBWF1.dest_line2_state
      feature_name =      (S) Call Back When Free

    NAME : CBWF1.feature_name
30   local_line_state =      (S) idle

    NAME : CBWF1.local_line_state
      location_attachments =      (S) local

35   NAME : CBWF1.location_attachments
      rank =                  (I) Unknown
      sequence_number =      (I) 1

    NAME : CBWF1.sequence_number
40   trigger_event_location =      (S) local

    NAME : CBWF1.trigger_event_location
      trigger_event_type =      (S) control_code

45   NAME : CBWF1.trigger_event_type

```

NAME : CBWF2  
CLASSES :  
    feature\_states

5   PROPERTIES :  
    cascade\_attachments =       (S) Call Diversion,Call Waiting,Call Divert On Busy

NAME : CBWF2.cascade\_attachments  
    caused\_local\_event =       (S) seize

10   NAME : CBWF2.caused\_local\_event  
    caused\_remote\_event1 =     (S) seize

NAME : CBWF2.caused\_remote\_event1  
15   caused\_remote\_event2 =     (S) none

NAME : CBWF2.caused\_remote\_event2  
    dest\_line1\_state = (S) busy

20   NAME : CBWF2.dest\_line1\_state  
    dest\_line2\_state = (S) any

NAME : CBWF2.dest\_line2\_state  
    feature\_name =       (S) Call Back When Free

25   NAME : CBWF2.feature\_name  
    local\_line\_state = (S) any

NAME : CBWF2.local\_line\_state

30   location\_attachments =       (S) local,local,local

NAME : CBWF2.location\_attachments  
    rank =                   (I) Unknown  
    sequence\_number =       (I) 2

35   NAME : CBWF2.sequence\_number  
    trigger\_event\_location =   (S) remote

NAME : CBWF2.trigger\_event\_location

40   trigger\_event\_type =       (S) clear

NAME : CBWF2.trigger\_event\_type

45   **Objects describing the *Call diversion* feature**

NAME : CD1

CLASSES :

feature\_states

PROPERTIES :

cascade\_attachments = (S) none

5

NAME : CD1.cascade\_attachments

caused\_local\_event = (S) announcement

NAME : CD1.caused\_local\_event

10 caused\_remote\_event1 = (S) none

NAME : CD1.caused\_remote\_event1

caused\_remote\_event2 = (S) none

15 NAME : CD1.caused\_remote\_event2

dest\_line1\_state = (S) any

NAME : CD1.dest\_line1\_state

dest\_line2\_state = (S) any

20

NAME : CD1.dest\_line2\_state

feature\_name = (S) Call Diversion

NAME : CD1.feature\_name

25 local\_line\_state = (S) any

NAME : CD1.local\_line\_state

location\_attachments = (S) local

30 NAME : CD1.location\_attachments

rank = (I) Unknown

sequence\_number = (I) 1

NAME : CD1.sequence\_number

35 trigger\_event\_location = (S) local

NAME : CD1.trigger\_event\_location

trigger\_event\_type = (S) control code

40 NAME : CD1.trigger\_event\_type

NAME : CD2

CLASSES :

feature\_states

45 PROPERTIES :

cascade\_attachments = (S) Call Waiting, Call Diversion

NAME : CD2.cascade\_attachments  
caused\_local\_event = (S) none

5 NAME : CD2.caused\_local\_event  
caused\_remote\_event1 = (S) seize

NAME : CD2.caused\_remote\_event1  
caused\_remote\_event2 = (S) none

10 NAME : CD2.caused\_remote\_event2  
dest\_line1\_state = (S) any

NAME : CD2.dest\_line1\_state  
15 dest\_line2\_state = (S) any

NAME : CD2.dest\_line2\_state  
feature\_name = (S) Call Diversion

20 NAME : CD2.feature\_name  
local\_line\_state = (S) any

NAME : CD2.local\_line\_state  
location\_attachments = (S) local

25 NAME : CD2.location\_attachments  
rank = (I) Unknown  
sequence\_number = (I) 2

30 NAME : CD2.sequence\_number  
trigger\_event\_location = (S) local

NAME : CD2.trigger\_event\_location  
trigger\_event\_type = (S) seize

35 NAME : CD2.trigger\_event\_type

NAME : CD3  
CLASSES :

40 feature\_states  
PROPERTIES :  
cascade\_attachments = (S) none

NAME : CD3.cascade\_attachments  
45 caused\_local\_event = (S) none

NAME : CD3.caused\_local\_event  
 caused\_remote\_event1 = (S) clear

NAME : CD3.caused\_remote\_event1  
 5 caused\_remote\_event2 = (S) none

NAME : CD3.caused\_remote\_event2  
 dest\_line1\_state = (S) busy

10 NAME : CD3.dest\_line1\_state  
 dest\_line2\_state = (S) any

NAME : CD3.dest\_line2\_state  
 feature\_name = (S) Call Diversion

15 NAME : CD3.feature\_name  
 local\_line\_state = (S) any

NAME : CD3.local\_line\_state

20 location\_attachments = (S) local

NAME : CD3.location\_attachments  
 rank = (I) Unknown  
 sequence\_number = (I) 3

25 NAME : CD3.sequence\_number  
 trigger\_event\_location = (S) local

NAME : CD3.trigger\_event\_location  
 30 trigger\_event\_type = (S) clear

NAME : CD3.trigger\_event\_type

**Objects describing the *Call waiting* feature**

35 NAME : CW1  
 CLASSES :  
 feature\_states  
 PROPERTIES :  
 cascade\_attachments = (S) none

40 NAME : CW1.cascade\_attachments  
 caused\_local\_event = (S) announcement

NAME : CW1.caused\_local\_event  
 45 caused\_remote\_event1 = (S) none

NAME : CW1.caused\_remote\_event1  
caused\_remote\_event2 = (S) none

5 NAME : CW1.caused\_remote\_event2  
dest\_line1\_state = (S) any

NAME : CW1.dest\_line1\_state  
dest\_line2\_state = (S) any

10 NAME : CW1.dest\_line2\_state  
feature\_name = (S) Call Waiting

NAME : CW1.feature\_name

15 local\_line\_state = (S) idle

NAME : CW1.local\_line\_state  
location\_attachments = (S) local

20 NAME : CW1.location\_attachments  
rank = (I) Unknown  
sequence\_number = (I) 1

NAME : CW1.sequence\_number

25 trigger\_event\_location = (S) local

NAME : CW1.trigger\_event\_location  
trigger\_event\_type = (S) control code

30 NAME : CW1.trigger\_event\_type

NAME : CW2

CLASSES :

feature\_states

35 PROPERTIES :

cascade\_attachments = (S) none

NAME : CW2.cascade\_attachments  
caused\_local\_event = (S) beep

40 NAME : CW2.caused\_local\_event  
caused\_remote\_event1 = (S) none

NAME : CW2.caused\_remote\_event1

45 caused\_remote\_event2 = (S) announcement

NAME : CW2.caused\_remote\_event2  
dest\_line1\_state = (S) call in progress

NAME : CW2.dest\_line1\_state  
5 dest\_line2\_state = (S) dialling

NAME : CW2.dest\_line2\_state  
feature\_name = (S) Call Waiting

10 NAME : CW2.feature\_name  
local\_line\_state = (S) call in progress

NAME : CW2.local\_line\_state  
location\_attachments = (S) local

15 NAME : CW2.location\_attachments  
rank = (I) Unknown  
sequence\_number = (I) 2

20 NAME : CW2.sequence\_number  
trigger\_event\_location = (S) local

NAME : CW2.trigger\_event\_location  
trigger\_event\_type = (S) seize

25 NAME : CW2.trigger\_event\_type

NAME : CW3a  
CLASSES :

30 feature\_states  
PROPERTIES :  
cascade\_attachments = (S) none

NAME : CW3a.cascade\_attachments

35 caused\_local\_event = (S) announcement

NAME : CW3a.caused\_local\_event  
caused\_remote\_event1 = (S) clear

40 NAME : CW3a.caused\_remote\_event1  
caused\_remote\_event2 = (S) none

NAME : CW3a.caused\_remote\_event2  
dest\_line1\_state = (S) call in progress

45 NAME : CW3a.dest\_line1\_state

dest\_line2\_state = (S) call in progress

NAME : CW3a.dest\_line2\_state  
feature\_name = (S) Call Waiting

5 NAME : CW3a.feature\_name  
local\_line\_state = (S) call in progress

NAME : CW3a.local\_line\_state

10 location\_attachments = (S) local

NAME : CW3a.location\_attachments  
rank = (I) Unknown  
sequence\_number = (I) 3

15 NAME : CW3a.sequence\_number  
trigger\_event\_location = (S) local

NAME : CW3a.trigger\_event\_location

20 trigger\_event\_type = (S) control code

NAME : CW3a.trigger\_event\_type

NAME : CW3b

25 CLASSES :  
feature\_states  
PROPERTIES :  
cascade\_attachments = (S) none

30 NAME : CW3b.cascade\_attachments  
caused\_local\_event = (S) announcement

NAME : CW3b.caused\_local\_event  
caused\_remote\_event1 = (S) none

35 NAME : CW3b.caused\_remote\_event1  
caused\_remote\_event2 = (S) clear

NAME : CW3b.caused\_remote\_event2

40 dest\_line1\_state = (S) call in progress

NAME : CW3b.dest\_line1\_state  
dest\_line2\_state = (S) call in progress

45 NAME : CW3b.dest\_line2\_state  
feature\_name = (S) Call Waiting

NAME : CW3b.feature\_name  
local\_line\_state = (S) call in progress

5 NAME : CW3b.local\_line\_state  
location\_attachments = (S) local

NAME : CW3b.location\_attachments  
rank = (I) Unknown

10 sequence\_number = (I) 3

NAME : CW3b.sequence\_number  
trigger\_event\_location = (S) local

15 NAME : CW3b.trigger\_event\_location  
trigger\_event\_type = (S) control code

NAME : CW3b.trigger\_event\_type

Objects describing the *Call divert on no reply* feature

20 NAME : DNRI  
CLASSES :  
feature\_states

PROPERTIES :

25 cascade\_attachments = (S) none

NAME : DNRI.cascade\_attachments  
caused\_local\_event = (S) announcement

30 NAME : DNRI.caused\_local\_event  
caused\_remote\_event1 = (S) none

NAME : DNRI.caused\_remote\_event1  
caused\_remote\_event2 = (S) none

35 NAME : DNRI.caused\_remote\_event2  
dest\_line1\_state = (S) any

NAME : DNRI.dest\_line1\_state  
dest\_line2\_state = (S) any

40 NAME : DNRI.dest\_line2\_state  
feature\_name = (S) Call Divert on No Reply

45 NAME : DNRI.feature\_name

local\_line\_state = (S) idle

NAME : DNR1.local\_line\_state  
location\_attachments = (S) local

5 NAME : DNR1.location\_attachments  
rank = (I) Unknown  
sequence\_number = (I) 1

10 NAME : DNR1.sequence\_number  
trigger\_event\_location = (S) local

NAME : DNR1.trigger\_event\_location  
trigger\_event\_type = (S) control code

15 NAME : DNR1.trigger\_event\_type

NAME : DNR2

CLASSES :

20 feature\_states

PROPERTIES :

cascade\_attachments = (S) none

NAME : DNR2.cascade\_attachments

25 caused\_local\_event = (S) none

NAME : DNR2.caused\_local\_event  
caused\_remote\_event1 = (S) seize

30 NAME : DNR2.caused\_remote\_event1  
caused\_remote\_event2 = (S) none

NAME : DNR2.caused\_remote\_event2  
dest\_line1\_state = (S) any

35 NAME : DNR2.dest\_line1\_state  
dest\_line2\_state = (S) any

NAME : DNR2.dest\_line2\_state

40 feature\_name = (S) Call Divert on No Reply

NAME : DNR2.feature\_name  
local\_line\_state = (S) ringing no reply

45 NAME : DNR2.local\_line\_state  
location\_attachments = (S) local

NAME : DNR2.location\_attachments  
rank = (I) Unknown  
sequence\_number = (I) 2  
5  
NAME : DNR2.sequence\_number  
trigger\_event\_location = (S) local  
  
NAME : DNR2.trigger\_event\_location  
10 trigger\_event\_type = (S) timeout  
  
NAME : DNR2.trigger\_event\_type  
  
NAME : DNR3  
15 CLASSES :  
feature\_states  
PROPERTIES :  
cascade\_attachments = (S) none  
  
20 NAME : DNR3.cascade\_attachments  
caused\_local\_event = (S) none  
  
NAME : DNR3.caused\_local\_event  
caused\_remote\_event1 = (S) clear  
25  
NAME : DNR3.caused\_remote\_event1  
caused\_remote\_event2 = (S) none  
  
NAME : DNR3.caused\_remote\_event2  
30 dest\_line1\_state = (S) busy  
  
NAME : DNR3.dest\_line1\_state  
dest\_line2\_state = (S) any  
  
35 NAME : DNR3.dest\_line2\_state  
feature\_name = (S) Call Divert on No Reply  
  
NAME : DNR3.feature\_name  
local\_line\_state = (S) any  
40  
NAME : DNR3.local\_line\_state  
location\_attachments = (S) local  
  
NAME : DNR3.location\_attachments  
45 rank = (I) Unknown  
sequence\_number = (I) 3

NAME : DNR3.sequence\_number  
trigger\_event\_location = (S) local

5 NAME : DNR3.trigger\_event\_location  
trigger\_event\_type = (S) clear

NAME : DNR3.trigger\_event\_type

Objects describing the *Call divert on busy* feature

10 NAME : DOB1  
CLASSES :  
feature\_states  
PROPERTIES :  
15 cascade\_attachments = (S) none

NAME : DOB1.cascade\_attachments  
caused\_local\_event = (S) announcement

20 NAME : DOB1.caused\_local\_event  
caused\_remote\_event1 = (S) none

NAME : DOB1.caused\_remote\_event1  
caused\_remote\_event2 = (S) none

25 NAME : DOB1.caused\_remote\_event2  
dest\_line1\_state = (S) any

NAME : DOB1.dest\_line1\_state

30 dest\_line2\_state = (S) any

NAME : DOB1.dest\_line2\_state  
feature\_name = (S) Call Divert on Busy

35 NAME : DOB1.feature\_name  
local\_line\_state = (S) idle

NAME : DOB1.local\_line\_state  
location\_attachments = (S) local

40 NAME : DOB1.location\_attachments  
rank = (I) Unknown  
sequence\_number = (I) 1

45 NAME : DOB1.sequence\_number

trigger\_event\_location = (S) local  
NAME : DOB1.trigger\_event\_location  
trigger\_event\_type = (S) control code  
5  
NAME : DOB1.trigger\_event\_type  
  
NAME : DOB2  
CLASSES :  
10 feature\_states  
PROPERTIES :  
cascade\_attachments = (S) none  
  
NAME : DOB2.cascade\_attachments  
15 caused\_local\_event = (S) none  
  
NAME : DOB2.caused\_local\_event  
caused\_remote\_event1 = (S) seize  
  
20 NAME : DOB2.caused\_remote\_event1  
caused\_remote\_event2 = (S) none  
  
NAME : DOB2.caused\_remote\_event2  
dest\_line1\_state = (S) any  
25  
NAME : DOB2.dest\_line1\_state  
dest\_line2\_state = (S) any  
  
NAME : DOB2.dest\_line2\_state  
30 feature\_name = (S) Call Divert on Busy  
  
NAME : DOB2.feature\_name  
local\_line\_state = (S) busy  
  
35 NAME : DOB2.local\_line\_state  
location\_attachments = (S) local  
  
NAME : DOB2.location\_attachments  
rank = (I) Unknown  
40 sequence\_number = (I) 2  
  
NAME : DOB2.sequence\_number  
trigger\_event\_location = (S) local  
  
45 NAME : DOB2.trigger\_event\_location  
trigger\_event\_type = (S) seize

NAME : DOB2.trigger\_event\_type

NAME : DOB3

5 CLASSES :

feature\_states

PROPERTIES :

cascade\_attachments = (S) none

10 NAME : DOB3.cascade\_attachments

caused\_local\_event = (S) none

NAME : DOB3.caused\_local\_event

caused\_remote\_event1 = (S) clear

15 NAME : DOB3.caused\_remote\_event1

caused\_remote\_event2 = (S) none

NAME : DOB3.caused\_remote\_event2

20 dest\_line1\_state = (S) busy

NAME : DOB3.dest\_line1\_state

dest\_line2\_state = (S) any

25 NAME : DOB3.dest\_line2\_state

feature\_name = (S) Call Divert on Busy

NAME : DOB3.feature\_name

local\_line\_state = (S) any

30 NAME : DOB3.local\_line\_state

location\_attachments = (S) local

NAME : DOB3.location\_attachments

35 rank = (I) Unknown

sequence\_number = (I) ;

NAME : DOB3.sequence\_number

trigger\_event\_location = (S) local

40 NAME : DOB3.trigger\_event\_location

trigger\_event\_type = (S) clear

NAME : DOB3.trigger\_event\_type

**Objects describing a new service feature**

NAME : next\_feature\_state

**PROPERTIES :**

cascade\_attachments = (S) none

5

NAME : next\_feature\_state.cascade\_attachments

caused\_local\_event = (S) Unknown

caused\_remote\_event1 = (S) Unknown

caused\_remote\_event2 = (S) Unknown

10

dest\_line1\_state = (S) Unknown

dest\_line2\_state = (S) Unknown

feature\_name = (S) Unknown

local\_line\_state = (S) Unknown

location\_attachments = (S) local

15

NAME : next\_feature\_state.location\_attachments

sequence\_number = (I) Unknown

trigger\_event\_location = (S) Unknown

trigger\_event\_type = (S) Unknown

**A temporary object**

NAME : temp

**PROPERTIES :**

returnval = (1) Unknown

CLAIMS

1. A system for detecting interaction between services running on a telecommunications network comprising:
  - a computer expert system including:
    - 5 a) a data store programmed with data representing attributes of service features;
    - b) a rule store programmed with rules which relate feature attributes to interaction behaviours; and
    - c) an inference engine which is connected to the data store and to
  - 10 the rule store and which is arranged to process the data and the rules, thereby detecting any interaction between the services.
2. A system according to claim 1, in which the data store includes a plurality of objects including, for each feature which is represented in the data store, a set of objects corresponding to different respective state transitions of the feature.
- 15 3. A system according to claim 2, in which each of the said set of objects includes a sequence number corresponding to the position of the respective state transition in the sequence of execution of the feature and at least some of the rules in the rule store reason over the values of the sequence numbers.
- 20 4. A system according to any claim 2 or 3, in which the objects are arranged in a hierarchy of superclasses and subclasses of the superclasses, and some of the rules reason over superclasses and others of the rules reason over subclasses.
- 25 5. A telecommunications network including a system according to any one of claims 1 to 4.
- 30 6. A method of detecting interaction between services running on a telecommunications network comprising:
  - programming a computer expert system including an inference engine with data representing attributes of service features and with rules relating feature attributes to interaction behaviours; and

processing the said data and the said rules in the inference engine and detecting thereby any interaction between the said services.

7. A method of operating a telecommunications network comprising:
  - 5 programming a computer expert system with data representing attributes of service features and with rules relating feature attributes to interaction behaviours;
    - processing the said data and the said rules in an inference engine and detecting thereby any interaction between the said services; and
  - 10 modifying the operation of the network when any interaction is detected.
8. A method according to claim 6 or 7, in which the said data are stored as a plurality of objects which include, for each feature which is represented, a set of objects corresponding to different respective state transition of the feature.
  - 15 9. A method according to claim 8, including storing a sequence number for each of the objects in the said set, where the sequence number corresponds to the position of the respective state transition in the sequence of execution of the feature and in which at least some of the rules reason over the values of the sequence numbers.
  - 20 10. A method according to claim 8 or 9, in which the objects are arranged in a hierarchy of superclasses and subclasses of the superclasses, and some of the rules reason over superclasses and others of the rules reason over subclasses.

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Fig.1.

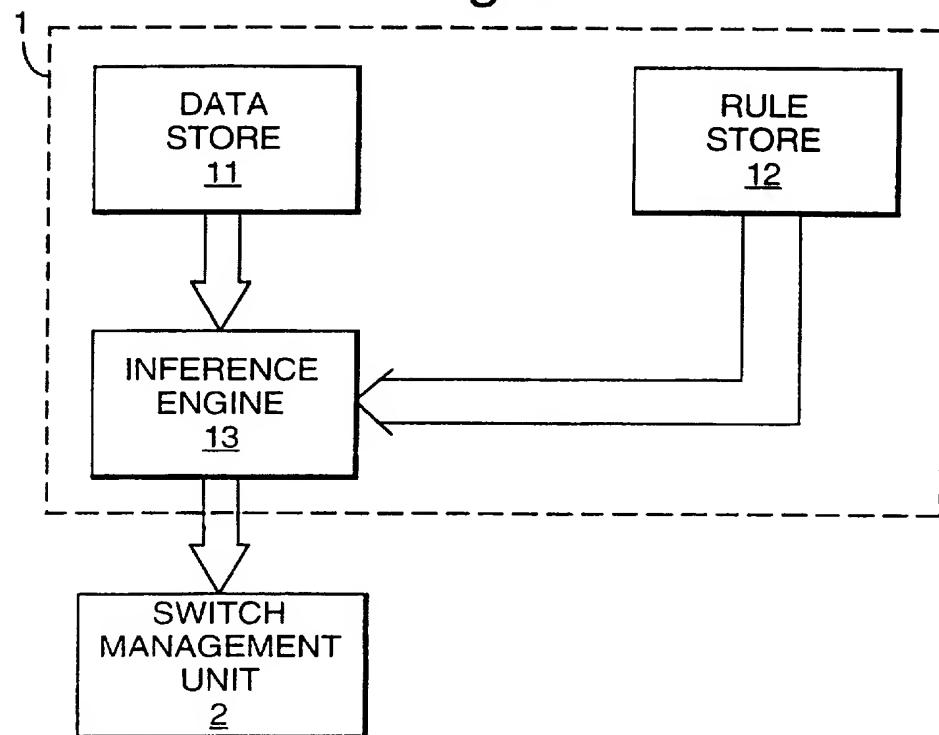
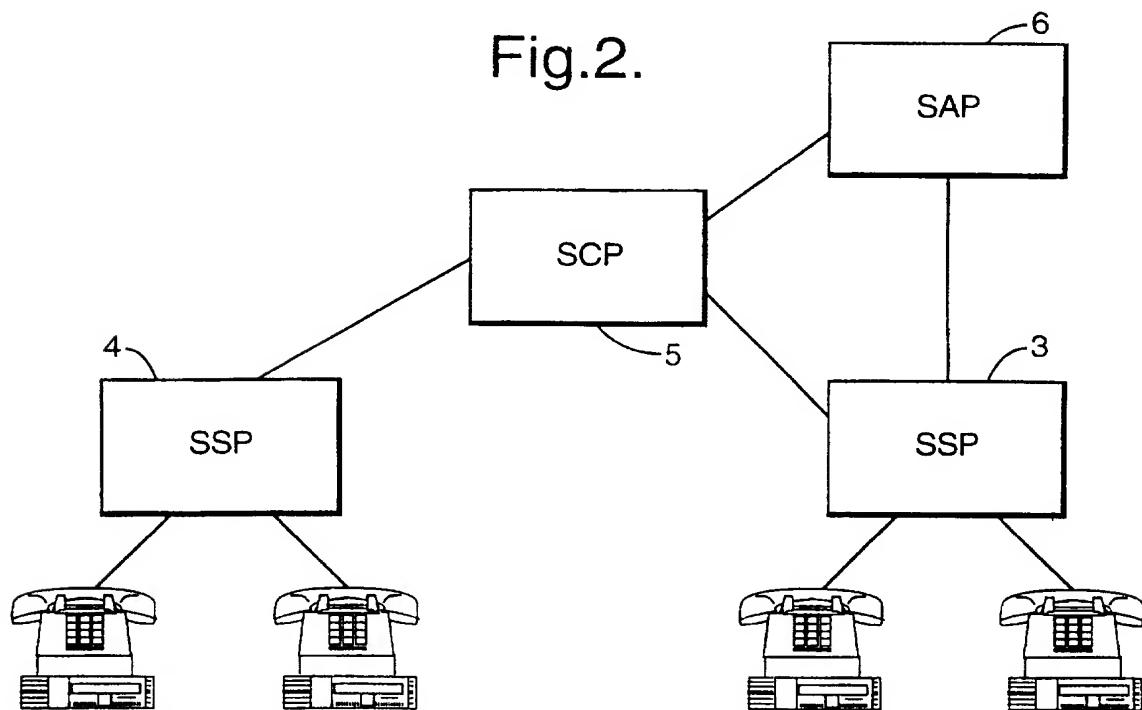
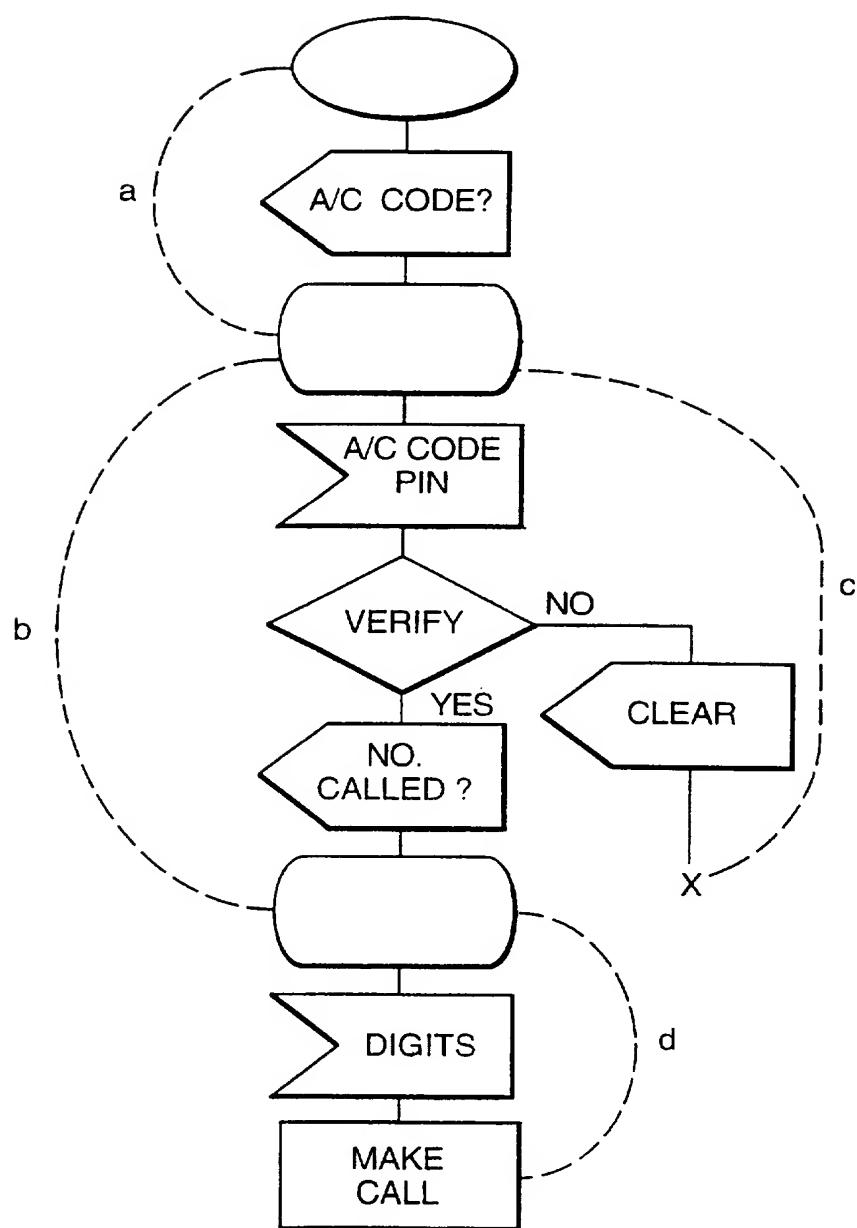


Fig.2.



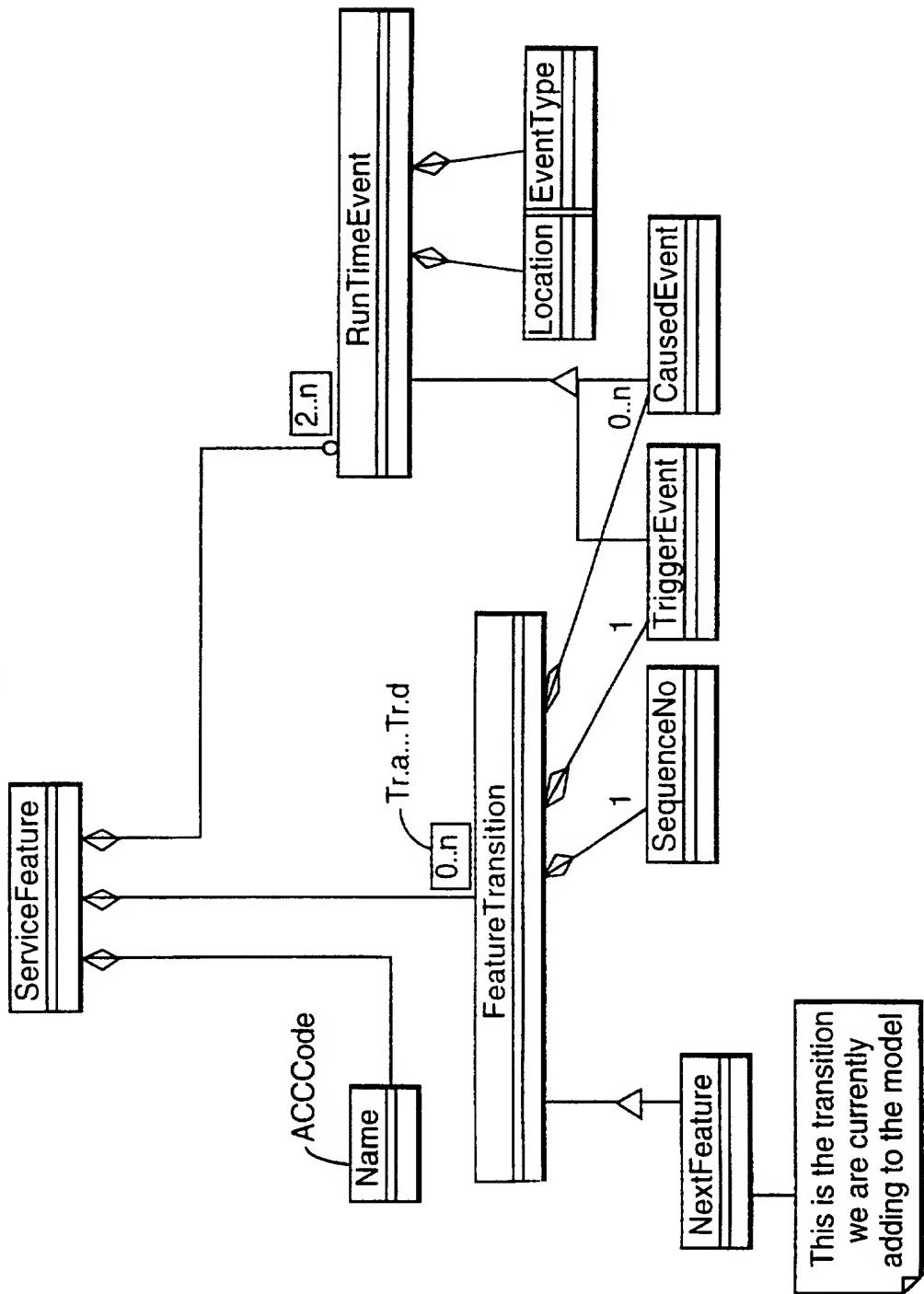
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Fig.3.



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Fig.4.



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Fig.5.

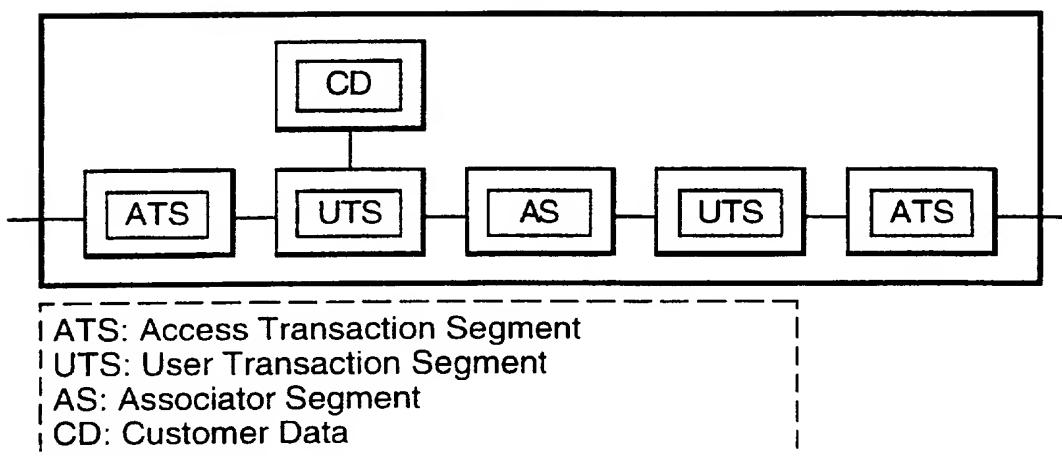
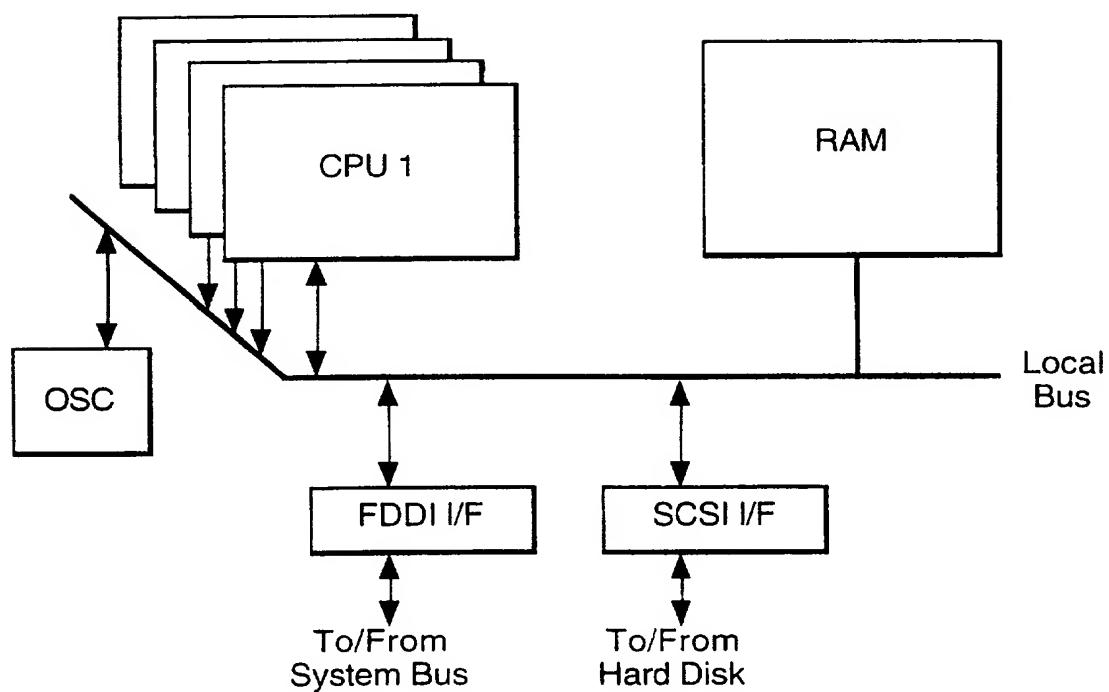


Fig.6.



# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 97/02505

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC 6 H04Q3/00

According to International Patent Classification(IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>BROTHERS ET AL.: "Feature interaction detection"          INTERNATIONAL CONFERENCE ON COMMUNICATIONS,          vol. 3, 23 - 26 May 1993, GENEVA CH,          pages 1553-1557, XP000448395          see page 1555, left-hand column, paragraph 3 - page 1556, left-hand column, paragraph 3; figures 2,3</p> <p>---</p> <p style="text-align: right;">-/--</p>	1,2,5-8



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

**1 Special categories of cited documents :**

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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1

Date of the actual completion of the international search

1 December 1997

Date of mailing of the international search report

12/12/1997

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Authorized officer

Lambley, S

## INTERNATIONAL SEARCH REPORT

Inte... onal Application No
PCT/GB 97/02505

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	HARADA ET AL.: "A conflict detection support method for telecommunication service descriptions" IEICE TRANSACTIONS ON COMMUNICATIONS, vol. E75-B, no. 10, October 1992, TOKYO JP, pages 986-997, XP000324946 see page 987, right-hand column, line 12 - page 989, left-hand column, last line ----	1,2,5-8
A	WO 93 18606 A (BELL ATLANTIC NETWORK SERVICES) 16 September 1993 see page 62, line 13 - page 63, line 15 ----	1,5-7
A	BRAITHWAITE ET AL.: "Towards automated detection of feature interactions" FEATURE INTERACTIONS IN TELECOMMUNICATIONS SYSTEMS, 8 - 10 May 1994, AMSTERDAM NL, pages 36-59, XP000593307 see page 47, line 31 - page 49, line 21 ----	1,2,5-8
A	BOSTRÖM ET AL.: "Feature interaction detection and resolution in the Delphi framework" FEATURE INTERACTIONS IN TELECOMMUNICATIONS SYSTEMS III, 11 - 13 October 1995, AMSTERDAM NL, pages 157-172, XP000593331 -----	

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 97/02505

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9318606 A	16-09-93	US 5353331 A	04-10-94
		US 5469496 A	21-11-95
		US 5579379 A	26-11-96
		US 5506887 A	09-04-96
		US 5664005 A	02-09-97
		US 5610972 A	11-03-97